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THE
LARYNGOSCOPE.

VOL. LVI MARCH, 1946. No. 3

A REVIEW OF THE AVAILABLE LITERATURE ON THE LARYNX AND LARNGEAL SURGERY FOR 1945.

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With the war's end in 1945, a number of papers dealing with the practice of otorhinolaryngology in Army General Hospitals have been published. One by Maj. I. Jerome Hauser,[1] Medical Corps, Army of the United States, speaks of the diseases of the larynx and trachea. Taking up the symptom of hoarseness, he states that he has seen, of course, a large number of patients with hoarseness due to acute laryngitis complicating acute respiratory infection. He considers under this head, however, only 49 soldiers admitted to the hospital, whose presenting symptom was chronic hoarseness. The various types of chronic hoarseness were distributed as follows: Aphonia, hysterical, 13; carcinoma of the larynx, one; laryngitis, chronic, 18; papilloma of the larynx, 15; paralysis of a vocal cord, two.

One soldier had an extensive carcinoma of the larynx, proved by biopsy. Because of obstructive symptoms, tracheotomy was done, and since the lesion was considered inoperable, the patient was transferred to another general hospital for treatment with high voltage Roentgen rays.

In the 18 patients with a diagnosis of chronic laryngitis, they were unable to demonstrate tuberculosis, syphilis or any other chronic infectious granuloma as the cause. After elimination of infection in the nose and throat, and a period of

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prolonged vocal rest, 14 of them showed sufficient improvement to return to military duty; the remaining four were separated from the service. In the 15 instances of papilloma of the larynx, the polyps were removed through a Jackson laryngoscope. Each polyp was examined microscopically, but none of them showed evidence of cancer. Two patients were seen in whom the chronic hoarseness was due to paralysis of one of the vocal cords. Although such etiologic factors as a thickened pleura, a mediastinal mass and lesions of the central nervous system were carefully considered, they were unable to demonstrate any definite cause in either of these cases.

It is of interest to know the impressions of otorhinolaryngology in some of the occupied territories of the Allied forces, and Brig. W. I. Daggett[2] gives his views from Germany. Speaking of carcinoma of the larynx, he states that in other countries the treatment of this condition varies considerably with the operative skill and humanity of the surgeon. Prof. Seiffert, whose operative dexterity is outstanding, performs total laryngectomy upon cases which most surgeons would treat with radiation; he utilizes one incision, which might be described as "left paramedian," and his results are undoubtedly good both from the viewpoint of rapid healing and freedom from recurrence. In general, there is a much greater tendency to fenestration of the thyroid cartilage and application of radium needles. This is probably due to the fact that teleradiation is virtually nonexistent.

The greatest diversity of opinion relates to the treatment of early carcinoma confined to one cord when there is no limitation of movement. Both Seiffert and Richter claim excellent results when the growth is very small and free from the anterior commissure, by biting it out with punch forceps large enough to embrace healthy tissue. This is done by direct or indirect laryngoscopy under local analgesia. Hobst favors the clamp (devised by Kraint) which contains a radium needle in each jaw. Under local analgesia (by direct or indirect vision) the cord is embraced by the clamp which

is held in position by pins transfixing the cord above and below, wide of the growth laterally.

The patient who has previously been given morphia and scopolamine retains this instrument for the prescribed time; on the average, five treatments are given. It is claimed that the clamp is well tolerated and that respiratory distress does not commonly occur, but Daggett was unable to check this. Laryngofissure is acknowledged by other surgeons as the best treatment when the cord is freely movable; when doubt arises, they have recourse to radium application after cartilage fenestration.

It is interesting to note that few laryngologists have any faith in the Broder classification as a help in selecting the method of treatment, or as a guide to the prospects of curability.

In carcinoma of the tonsil, base of tongue and epiglottis, cases which in this country would be treated by radiation are much more commonly dealt with by wide excision with a diathermy knife, followed by electrocoagulation of the residual raw area. At Heidelberg he saw cases which had been treated by this method and their subsequent disability was negligible despite an almost frightening loss of tissue.

Lumsden[3] in reporting injuries to the larynx reports: A leech in the trachea was encountered in a Palestinian Arab who had been drinking direct from a "wadi." The patient himself suggested the probable cause of his hemopysis and discomfort. The leech was detached by the effects of direct application of 10 per cent cocaine, and was removed by the bronchoscope.

The author also reports bilateral vocal cord paralysis with recovery in a case of typhus.

Zinn[4] in writing on the significance of hoarseness emphasizes the prime importance of hoarseness, alone or accompanied by other symptoms, as a warning signal of "danger ahead." He feels very strongly that the significance of hoarseness has not been given the recognition it deserves in view of

the frequency with which this symptom is encountered in various diseases and the seriousness of the conditions which follow in its wake. This is undoubtedly due, in part, to the fact that nearly everybody, at one time or another, has been hoarse from minor ailments and has recovered uneventfully.

It is the duty of the medical profession to educate the public concerning hoarseness and arouse them to the dangerous sequelae of this symptom.

He further states that it is now pretty generally conceded that 80 per cent of all cases of carcinoma of the larynx are curable by operation if the diagnosis is made while the disease is still intrinsic.

Smith,[5] in connection with a series of cases of laryngectomy reported by Lewis, found that in 100 patients an average of 11½ months had elapsed between the onset of marked hoarseness and the diagnosis of carcinoma of the larynx. The delay affected unfavorably the prognosis of laryngectomy. The practice of prescribing some remedy for hoarseness before a definite diagnosis is made cannot be too strongly discouraged.

In conclusion, he urges the persistent and untiring support of a program of education for the general practitioner and the public on the prime importance of hoarseness as a warning of coming danger. In lectures to medical students, stress the necessity of careful, not casual examinations of the larynx. Insist that all students learn to make full and complete examinations and diagnoses guided by their findings. Let's reduce death from laryngeal disease by early diagnosis and treatment.

SPEECH AND VOICE DISORDERS.

Greene,[6] speaking of speech and voice disorders due to oral and laryngeal defects, states that laryngectomy robs the patient of the two essentials for producing voice: *1.* a mechanism capable of vibrating the vocal cords; and *2.* a moving column of air with which to set this mechanism in vibration.

Since the first successful laryngectomy was performed by Billroth, in 1873, means have been sought to compensate for the loss of these two essentials and thus restore some measure of voice and speech to the patient who has undergone a laryngectomy. As it appeared manifestly impossible for such a patient to talk without artificial aid, a mechanical larynx operating on the reed principle was devised for him. This instrument has several obvious disadvantages and, fortunately, it is usually possible for the patient (by developing an esophageal voice) to learn to speak again without the aid of such a device. (In my experience with laryngectomized patients, I am convinced that they will talk if they, the patients, make up their minds to do it.—H. B. O.)

Time does not permit the author's going into the technique of developing an esophageal voice, but essentially it consists of swallowing a quantity of air into the esophagus and then slowly expelling it. Usually there is in the pharynx sufficient loose tissue of one sort or another to serve as a vibrating mechanism and thus to produce sound when the air is regurgitated. The patient learns to articulate as he produces the sound and he gradually perfects this ability to speak in his new voice.

Gatewood,[7] by means of a small catheter placed in one nostril, whereby the patient by means of a rubber bulb forces air into the nasopharynx, has helped the laryngectomized patient to acquire the knack of getting air into the pharynx. As total extirpation of the larynx is being performed more often, it becomes necessary for the laryngologist to interest himself in esophageal speech. The immediate training and production of a pseudo-voice in a laryngectomized person is now recognized as an integral part of the management of this disease, and the patient should not be completely dismissed until every possibility of his acquiring a new speech has been exhausted. There are several factors which influence the development of the esophageal voice: *1.* the will of the patient to learn, and *2.* the encouragement and confidence that may be imparted to the patient by one who has had a like operation and has acquired a satisfactory voice. (All those doing

laryngectomies should from time to time collect the patients and school them in the esophageal voice. I have done this for many years, from three to four times a year.—H. B. O.)

ARTIFICIAL RESPIRATION.

After a five-year survey of methods for artificial respiration, Ross[8] informs us that acute asphyxia requires immediate treatment if the patient is to recover, and seconds may mean the difference between recovery and death. As a result, laymen cannot wait for the arrival of a physician before instituting treatment, and rarely does a physician arrive before the critical period of treatment is over. Artificial respiration has thus been necessarily entrusted to the hands of nonmedical groups and individuals such as firemen, policemen and lifeguards.

Experimental work has been done in this field, but the results are not generally accepted as being conclusive. This is especially true of the Schafer prone pressure method, which depends on elastic recoil of the diaphragm for production of inspiration. The newly developed rocking method of Killick and Eve is unique in that it does not depend on elastic recoil. In this method the patient is alternately tipped back and forth on a stretcher, the weight of the viscera causing the diaphragm to move back and forth as a piston. This method is under trial in England but has not been used to any extent in this country.

Reports of cases of artificial respiration have been collected from the United States Coast Guard and from the Chicago, Los Angeles and Detroit fire departments, during the years 1940 through 1944. These organizations sent in reports on all cases, regardless of whether or not resuscitation occurred. A total of 3,352 reports was obtained.

There are reported 153 cases of acute asphyxia in which a resuscitator, a mechanical device for artificial respiration employing alternate blowing and sucking, resulted in revival. None of the patients, 80 of whom were newborn infants, showed evidence of injury as a result of this procedure.

There are reported 58 cases of acute asphyxia in which the Schafer prone pressure method was successful in resuscitation. In none of these cases nor in any of the additional 328 cases in which the Schafer prone measure method was used, either entirely or in part, was there any report of fractured ribs. Such injuries have been said to be a possible result of improper use of this method.

No instance of revival was reported in which more than 15 minutes elapsed between the cessation of breathing and the start of artificial respiration.

Victims of heart disease make up a large portion of the cases treated by the inhalator squads of the Chicago, Los Angeles and Detroit fire departments.

INFECTIONS OF THE NECK.

Penicillin — its use is being more and more employed as it becomes available for general use, and Gaines[9] reports using penicillin in deep infections of the neck, citing four patients with deep infection—two with Ludwig's angina and two with pharyngomaxillary abscess—all treated with penicillin. Only one patient was operated upon, and that was before the administration of penicillin began. All were seriously ill, their conditions well defined clinically, and all recovered. It is believed that penicillin will prove a most valuable agent in the treatment of patients with such infections.

ANESTHESIA.

Anesthesia for laryngofissure, Loftus-Dale,[10] London, advises against morphine. Pentobarbital sodium gr. 1.5. Then a block of the superior laryngeal nerves is done, then a field block is done which is bounded superiorly by the hyoid bone, laterally by the anterior borders of the sternomastoid and inferiorly by the suprasternal notch. Uses 20 to 30 cc. of anethaine with 1:4,000 adrenalin; 1:400,000 is required for the field block.

A needle is then introduced in the midline through the cricothyroid membrane to a depth of about 1 cm., the needle

point to be free in airway, through which 2 cc. of 10 per cent cocaine are injected very slowly, drop by drop, to anesthetize the mucous membrane. He cites very good results with the above anesthesia.

THE RESPIRATORY FUNCTION OF THE LARYNX.

A preliminary report on some observations on laryngeal innervation has been made by Murtagh,[11] in which he states that in general there are two functions of the larynx: first, its actions as a valve; second, its activity in phonation. Unanimous agreement as to individual muscle function, as to laryngeal innervation and as to laryngeal nerve sensitivity is lacking.

The valvular function of the larynx has been investigated by Longet, Wyllie, Brunton and Cash, Semon, Semon and Horsley, Negus and recently Pressman. Recent investigators have attributed a motor function to the internal branch of the superior laryngeal nerve in an attempt to explain the adduction of the vocal cords following injury to the recurrent laryngeal nerve. A recent tendency has developed to deviate from these established principles and to theorize without regard to the complete and exhaustive work of those men whose findings should be considered with great weight in any clinical discussion of laryngeal paralysis. Murtagh feels that he is able to substantiate and graphically illustrate a number of the principles previously established by Onodi and Lemere by obtaining graphic records of muscle response to muscle and to nerve stimulation.

From these and from similar records it appears that there are no afferent fibres in the recurrent. Stimulation of the central end of the cut nerve produces no changes which are recorded by the apparatus. Stimulation of the peripheral end of the cut nerve produces abrupt adduction, which is confined to the side stimulated. The slight change in respiration in these records appears only when the peripheral end of the nerve is stimulated and may be due to reflex changes brought

about by stimulation of the endings of the superior laryngeal nerve, internal branch, by changes in the glottic pressure.

This was repeated many times and at no time could he find evidence of motor function in the internal division of the superior laryngeal nerve. A ligature on this nerve produces a transient change in respiration with noteworthy changes in the glottic record. There is evidence that the cricothyroid is a strong adductor.

The movement of the cords laterally follows only when the only remaining adductor, the thyrocricoid muscle, is paralyzed by sectioning or blocking the external branch of the superior nerve.

He was able to find no evidence of motor function in the internal branch of the superior laryngeal nerve of the goat, nor was there any evidence of reflex changes following stimulation of the central end of the cut recurrent laryngeal nerve.

The internal branch of the superior laryngeal nerve carries afferent fibres involved in various reflexes, affecting glottic motion and altering respiration.

The cricothyroid muscle, or the thyrocricoid as it should more definitely be called, has a marked adductor function, a fact previously emphasized by Wagner, Onodi, Lemere and recently Iglauer. This muscle is responsible for maintaining the cord in the so-called median or paramedian position following complete recurrent laryngeal nerve paralysis.

Experimental evidence and visual observation indicate that following section of both recurrent laryngeal nerves, elimination of the function of the external branch of the superior laryngeal nerve produces a marked abduction of the vocal cords, increasing the laryngeal airway.

An increase of laryngeal pressure alters the character of respiration.

In their experiments they have merely substantiated graphically previous facts emphasized by Onodi and Lemere and others.

STROBOSCOPY.

Laryngeal stroboscopy — Perlman[12] points out the importance to the laryngologist of assessing vocal cord movement during phonation. He describes a practical method for making these observations, using a simple strobosope.

Stroboscopic findings in several illustrative cases of laryngeal disease are presented and discussed.

ACUTE LARYNGOTRACHEOBRONCHITIS.

In the treatment of this condition, Baum[13] states that there are certain fundamental conceptions concerning acute laryngotracheobronchitis which to his mind should govern its management:

1. Until there is more precise scientific information to the contrary, it appears to him that it is reasonable to assume that this is not a specific disease entity but a clinical syndrome produced by a combination of factors, certain of which are man-made.

2. He believes it to be primarily a virus infection, probably influenzal, with secondary invasion by various pathogens, most frequently the streptococcus, as is common in all virus infections of the respiratory tract.

3. The most important pathologic change encountered in laryngotracheobronchitis is mucosal and submucosal inflammatory edema of the larynx and the lower respiratory tract.

4. Its most urgent symptoms are those of respiratory obstruction produced by the presence of edematous swelling in the subglottic space.

5. Later symptoms of vast importance are those of respiratory obstruction from bronchial plugging, which he believes to be one of the man-made factors with which one must deal, or, better, which one must, if possible, prevent.

Successful management of laryngeal obstruction without tracheotomy also avoids those serious sequelae, progressive tracheobronchial dryness and subsequent formation of plugs, with obstruction, and is, therefore, greatly to be desired. In

spite of all efforts to the contrary, intubation or tracheotomy may become necessary. Intubation is the operation of choice, especially early, and a combination of both intubation and tracheotomy may frequently be of advantage to minimize tracheobronchial dryness. Breathing of moist, cool oxygen at all times and high humidity of the respired air, especially following tracheotomy, are fundamental in the management of this disease.

Otte[14] emphasizes the necessity of pediatricians and laryngologists collaborating together towards a perfect understanding of the complex symptomatology in different forms of croup.

Mentioning man's fight against this disease, he divides it into three periods: first, preserological; second, serological, and third, the most modern, tends to avoid asphyxia, endoscopic period. This latter method has been repeatedly used by Otte with such good results that he advocates the necessity of establishing endoscopic departments, especially in children's hospitals, because endoscopy in croup can avoid tracheotomy and intubation, leaving these methods to their strict indication.

He mentions Dr. Gilbert, Dr. Meyersburg and Dr. Silverburg's classification in the *Archives of Otolaryngology*, 1941, which divides into: Diphtheria or specific croup; false croup, or nonspecific croup.

Otte mentions these three forms of diphtheric croup, emphasizing the endoscopic treatment of the laryngotracheal and laryngotracheobronchial type, the latter previous tracheotomy.

False croup falls more under the pediatrician's treatment because of intimate relationship with general conditions and surroundings.

He believes the above mentioned authors' classification helps treatment in each case, especially in the most common type, this being edematous laryngitis.

DIPHTHERIA.

Kennedy[15] (Sheffield) reports a case of laryngeal diphtheria occurring in a female adult with pregnancy which necessitated tracheotomy, followed by delivery of a six months fetus, complicated by bronchopneumonia, treated with 60,000 units diphtheria antitoxin intramuscularly and 40,000 units intravenously and 16 gm. thiazamide intravenously, with no complications and complete recovery.

STENOSIS OF THE LARYNX.

In the treatment of stenosis of the larynx, Erich[16] in his excellent paper states that an extensive cicatricial stenosis of the larynx or the upper part of the trachea usually can be treated most successfully by an open operation through an incision in the neck; such direct exposure permits accurate excision of the thickened scar tissue producing the stricture. In those cases in which this precise method of re-establishing the normal dimensions of the laryngeal or tracheal lumen is to be employed, it is distinctly advantageous to divide the course of treatment into three separate stages: first, the surgical removal of the cicatrix; second, the mechanical prevention of a tendency toward narrowing or constriction of the newly-made lumen (over a long period, usually six months), and third, the plastic closure of the external tracheal opening.

Orton in his discussion of this paper states that the plan of therapy developed by Dr. New and Dr. Erich in the treatment of extensive cicatricial stenosis of the larynx or trachea, as usual, is typical of their clinic: concise, to the point and showing excellent results.

We all know that the treatment of extensive cicatricial stenosis of the larynx or trachea, after inflammatory or specific granuloma has been completely eradicated, is very tedious, and that the repair of these cases extends over a considerable period of time, necessitating prolonged hospitalization. We can all recall many patients in whom we have treated this type of stenosis with all the associated annoying detail, in which the treatment extended well over two years

before a normal airway could be re-established. Any procedure that diminishes this lengthy stay in the hospitals and simplifies the repeated dressings should be most acceptable. Dr. Erich's splendid paper describing in detail his procedure, in stages, certainly eliminates the former tedious ways and produces very gratifying results.

(I am in absolute accord with Dr. Erich when he states that the first step must be the adequate exposure of the tissue forming the stenosis. The exposure is necessary not only in this type of case, but in many other surgical procedures in laryngology and adequate exposure is absolutely essential. The removal of all scar tissue and replacing it with a skin graft and the method of making the molds and obdurator were of especial interest to me.—H. B. O.)

PARALYSIS OF THE LARYNX.

Fox[17] states that when hoarseness occurs following mastectomy for carcinoma of the breast the possibility of metastasis must be considered. In each of the six cases he presented in this group there was a period following mastectomy during which the patient enjoyed complete symptomatic freedom from disease. This period varied from 14 months to 12 years. The patient's well-being was then suddenly interrupted by changes in the voice, described as persistent hoarseness or huskiness. There were also intermittent weakness of the voice, a tendency of the voice to crack, and a nonproductive cough, unaccompanied by any evidence of infection of the respiratory tract. Dyspnea was severe in one patient and was experienced on exertion by the others. In each instance, however, it was the laryngeal disturbance which caused the patient to consult her physician.

In the treatment of abductor paralysis, Froeschels[18] points out that palsy of the recurrent nerve occurs frequently after struma operations. We know from the literature on this subject that these palsies are not always due to injuries to the nerve sustained during the operation (Rankin).

He further states that many authors (Amerbach) believe,

therefore, that disturbances of the circulation are sometimes responsible for this condition; particularly as the recurrent nerve is rich in sympathetic nerve elements. According to the less recent literature (Cisler), more than 50 per cent of the cases showed paresis or palsies in the region of the recurrent nerve after operations on the struma. This number has been remarkably reduced by modern surgical technique.

The method which Froeschels recommends has been called "pushing exercises," as the "pushing exercises" had proved highly successful with cases of severe palsy of the inferior laryngeal nerve.

In conclusion, he wishes to make it clear that he does not consider the pushing exercises to be effective in cases of paralysis due to an irreparable anatomic destruction; but such a destruction cannot be diagnosed with our clinical methods. This fact, too, indicates the pushing exercises in all cases of impaired or missing mobility of the muscles innervated by the recurrent nerve if no immediate surgical indication prevails.

CANCER OF THE LARYNX.

Schall[19] shows adaptations of seven charts on the treatment of cancer of the larynx, from simple laryngofissure to irradiation.

Snitman[20] points out the significance of histopathological study of serial sections. In his preliminary report, he observes that since the performance of the first total laryngectomy by Billroth and Czerny, in 1873, voluminous reports on various aspects of cancer of the larynx have appeared in the literature. Generally, they were concerned with problems of early diagnosis, modes of therapy, surgical techniques, histopathologic observations and radiosensitivity of the growths.

This present study, which was begun in October, 1943, deals with the results of a regular serial study of a specimen removed by thyrotomy.

This report concerns itself with the histologic study of a block of laryngeal tissue removed by thyrotomy. The lesion

was grossly seen involving only the middle and anterior thirds of the true left cord and not involving the anterior commissure. The block tissue included about 0.5 cm. of the anterior end of the right true and false cords. The microscopic study revealed incomplete removal of the cancer *in situ* of the right true cord.

Although the lesion involved almost exclusively the region of the glottic lip of the entire length of the true cord tissue, there was no subglottic or ventricular extension. The false cord was completely normal. The presence of a greater length of cancer *in situ* anterior to the hornifying carcinoma and only a slight amount posterior to it permits one to conclude that the lesion grew to the anterior commissure and extended to the opposite cord. This would tend to confirm previous clinical and histopathologic studies.

The lesion on the left cord had been well circumvented by normal epithelium. That of the right cord, however, showed incomplete removal, although grossly there could not be discerned any pathologic alterations.

This observation is in accord with the established fact that it is often difficult to make an accurate microscopic diagnosis from one portion of a tumor. An examination of serial sections of the entire mass is essential; therefore, it is sound to conclude that serial histologic study of laryngofissure specimens would prevent delay in the management of residual malignant neoplastic tissue.

C. L. Jackson and C. M. Norris[21] speak of the treatment of the intrinsic larynx by surgery or by some form of irradiation, or by a combination of these methods. In the surgical treatment, the choice lies between total laryngectomy and some form of partial laryngectomy.

Treatment by irradiation may mean the use of Roentgen rays, which are not generally administered by some form of "protracted fractional" (Coutard) technique; or the use of some form of radium, as, for example, the "saturation technique," with radium packs applied to the neck externally. In

certain cases radon (gold "seeds" containing radium emanations) or removable radium needles are inserted.

The technique of laryngofissure used by the authors at the Temple University Clinic is described; and the steps in laryngectomy are described, using the Vasconcelos Barretto's clamp.

Complications of laryngectomy — Sepsis is unquestionably the most common complication of laryngectomy; and they speak of the current use of the sulfa drugs and penicillin, both preoperatively and postoperatively, will doubtless also lower the incidence of sepsis, curtail its duration and lessen its severity when it does occur.

Hemorrhage should be a very rare postoperative complication in laryngectomy.

Pharyngeal fistula is not an uncommon complication of laryngectomy.

Results: Of course, without treatment, cancer of the larynx is 100 per cent fatal; but the prognosis of the treated cases is better than in cancer of most other parts of the body.

McCall and Stover,[22] in their review of 45 cases of laryngectomy for laryngeal cancer, state that until the advent of some as yet undiscovered chemical or biological agent to combat cancer, surgery offers the best hope in treatment of carcinoma of the larynx. Surgery, therefore, in cancer of the larynx must be thorough and complete, and hence radical. Many more patients would be saved if it were always remembered that there must be no compromise in dealing with carcinoma.

In this series of 45 cases in which laryngectomy was performed, two operations were done for extensive chondroma of the larynx. The remaining 43 patients had squamous carcinoma. There were no immediate postoperative deaths. Twenty-four cases of carcinoma were extrinsic, some of them extensive and advanced, and 19 were intrinsic. Two patients died of causes unrelated to cancer, and 12 died of recurrence

within two years after operation. Thirty-one patients (29 with carcinoma) are living. Eleven patients with carcinoma have survived for more than three years without recurrence. The longest survival period in this series is eight years. Of 24 patients who had preoperative training to acquire the ability to belch, only four failed to develop a satisfactory voice.

Rosedale[23] records the instance of a sarcoid involving the face and the larynx. This case of Boeck's sarcoid involving the face and the larynx is being reported because of the unusual distribution of the lesions and particularly because of the laryngeal involvement. Careful review of the "Quarterly Cumulative Index Medicus" has failed to disclose more than two reports of Boeck's sarcoid of the larynx.

The patient presented involvements of the face and the larynx, which histologically proved to be Boeck's sarcoid. Clinically, the lesions involved also the vestibules of the nose and the lips. The laryngeal lesion was obstructive. As far as is known, this is the third recorded instance of involvement of the larynx by Boeck's sarcoid.

Patterson,[24] in the treatment of carcinoma of the vocal lip by operation, states that the majority of laryngologists favor irradiation rather than surgery in the treatment of cancer of the larynx. (I do not think this is so in the United States.—H. B. O.)

He described his procedure — incision begins in the middle-line immediately above the thyroid cartilage and is carried outwards to right or left and gradually curved downwards till it reaches the middle of the posterior border of the thyroid ala; it then curves downwards and forwards, reaching the middle line at the lower border of the cricoid cartilage; from this point downwards in the mid-line as far as the suprasternal notch. The larynx thyroid isthmus and trachea are exposed in the usual manner. A tracheotomy is done. Instead of using shears to open larynx, the thyroid cartilage is cut or sawed through in the middle-line, avoiding injury to the underlying soft tissue. A parallel incision is then made about a quarter of an inch from the central incision through

the thyroid cartilage on the nonaffected side of the larynx. This portion of the thyroid cartilage is removed. The remainder of the operation is carried out by means of surgical diathermy. Bleeding controlled, tracheotomy tube removed, but the author keeps the wound open by placing a tape to which a stitch is inserted through the strap muscles on each side.

SARCOMA.

A case of rhabdomyomyxosarcoma of the larynx is reported by Glick.[25] In his article he records that in the practice of the average laryngologist, sarcoma of the larynx is rarely or never encountered. This is particularly true in the case of an infant or child, since no actual report of its occurrence in the very young could be found from a review of some of the older and also the more recent textbooks of pathology and the literature prior to 1943. A report of the following case is, therefore, submitted because of its rarity and also for its clinical interest from the standpoint of laryngeal findings, management and subsequent progress.

R. S., a 10-year-old white school boy, came under his care on Jan. 18, 1940, because of difficulty in breathing for two weeks and increasing hoarseness of one year's duration.

Mirror examination of the larynx was easily carried out. The base of the tongue, the epiglottis, larynx and surrounding parts were exposed. There was slight hypertrophy of the lingual tonsils but no redness. The epiglottis was normal in shape and slightly overhanging but did not interfere with a good view of the larynx. The aryepiglottic folds and the arytenoids, as well as the pyriform sinuses, appeared normal. The major portion of the laryngeal opening was filled with a smooth, soft, grayish-looking tumor mass, extending from the anterior commissure slightly below the left cord surface. This was approximately the size of a small lima bean.

Shortly after admission to the hospital, his dyspnea increased and a tracheotomy was promptly performed. In order to remove the tumor from the larynx completely, a laryngofissure was done.

The occurrence of the tumor in the boy's larynx, which upon removal and microscopic study, proved to be a mixed form of sarcoma is most unusual. Nearly all writers in the reports from the laryngological literature during the past 50 years agree that true sarcoma is uncommon; when encountered in the larynx, occurs in adults, is chiefly intrinsic,

shows little tendency to metastasize early, especially at the site of removal, and is found relatively more frequent in males.

Foster[26] also records a case of fibrosarcoma of the larynx in a male aged 31 years. Patient was referred to him, Dec. 9, 1943, on account of a laryngeal tumor with considerable dyspnea. The patient, who had been discharged from the Army on November 23, 1943, was the son of a physician in Dallas and had taken one year in medicine before enlisting.

On Aug. 10 and Aug. 23, attempts at removal were made through a direct laryngoscope, and on Sept. 3 another laryngoscopy was done and the larynx was reported free of growth; but again, on Oct. 11, another operation was done and some tissue removed. The patient was discharged, as above stated, on Nov. 23 and was apparently well except for coughing up dried, greenish crusts occasionally. He thinks he caught cold on the way home and had a slight hemoptysis. Breathing gradually became obstructed until he was referred to the author.

Examination by indirect laryngoscopy revealed a subglottic tumor which seemed to be attached anteriorly and which obstructed the airway to such an extent that there was considerable dyspnea; the examination was otherwise negative. An X-ray examination was made with the following report:

Operation on Dec. 11, 1943, under local anesthesia, the tumor was exposed by direct laryngoscopy and found to be attached to the anterior wall in the region of the cricoid isthmus. The greater part was removed with a snare and the base smoothed with punch forceps. The attachment was anterior and to the right and seemed to include the cricoid isthmus and the tracheal wall for a short distance. There was comparatively little bleeding. *Diagnosis:* Cellular fibroma of larynx. Fibrosarcoma?

A fibrosarcoma in this region is sufficiently rare to warrant reporting.

IRRADIATION.

In the treatment of inoperable cancer of the throat, Arbuckle, *et al.*,[27] give a follow-up of a previous report, and state that it is the purpose of their paper to report their experience in the treatment of far advanced or late cancer of the throat by an improved method of approach.

Of the 16 cases reported, eight are living and free of signs of cancer. All have normal deglutition and a good voice. Nearly all have a normal airway, but wear a small-size tracheotomy tube which they keep plugged.

Emphasis is placed on the importance of a new fundamental principle in the treatment of advanced cancer of the throat. The principle is founded on the removal of the thyroid cartilage before X-ray therapy is instituted. In their preliminary report of this work, they did not give credit to Hautant for his work for the reason that they were unaware of it until July 12, 1944, for which they apologize.

Attention is further called to the need for adequate dosage, careful evaluation of the X-ray reaction and supervision of accompanying generalized disease. The possibility of extending this form of treatment to earlier cancer may be considered.

Nielsen and Strandberg[28] state that in 600 cases of tumors of the upper respiratory and digestive tracts, 63 were intralaryngeal cancer. These are discussed particularly from the point of view of determining the comparative value of surgical and Roentgen treatment.

Daily irradiations were given over periods varying from three to eight weeks, with a total dosage of from 5,000 to 6,000 Roentgens, or, in some cases even 7,000 Roentgens. The tumor dose must be at least from 4,500 to 5,000 Roentgens. The primary results have been encouraging in these cases.

The table of results shows that 22 per cent of all patients remained symptom-free for five years or more; 33 per cent for three years or more; 46 per cent for one year or more;

and 49 per cent were rendered primarily free of symptoms. (Results still do not come up to surgery for laryngeal cancer.)

Watson and Lambert[29] describe the method of treating intrinsic carcinoma of the larynx by means of Chaoul "contact" X-rays. The ala of the thyroid cartilage on the affected side was ablated, a single dose of X-rays was delivered directly to the larynx and the wound then closed.

Indication for treatment — It was used in cases in which the growth was either confined to the cord, or extended beyond the cord at either end, the only proviso being that the growth was confined to the larynx and did not extend across the mid-line and did not involve cartilage.

Twenty-six cases were treated by this method. Alive and well, 13; dead, 12, with recurrence and death in nine.

Surgery still seems to offer better results in early carcinoma of the larynx.

Mustakallio[30] reports 238 cases of cancer of the larynx and hypopharynx treated at the Institute for Radiotherapy in Helsinki, Finland, since 1936.

The author gives the dividing line between the larynx and hypopharynx as the free edge of the epiglottis, down along the aryepiglottic folds to the arytenoid cartilages in the back. He also uses a third classification, consisting of cancer involving the epiglottis and adjacent areas, exclusive of cancer of base of tongue. These he called cancer of the anterior wall of the larynx.

Seventy per cent of this group had metastasis to the neck when they came for treatment, all males. In 130 of laryngeal carcinomas, three were females. In the hypopharyngeal group, 15 occurred in women. (The classification is rather confusing.—H. B. O.)

Laryngeal carcinoma, 130 cases. Thirty-eight lived five or more years and of these, nine were free of symptoms. In other words, 29 still had symptoms of carcinoma after five years.

Those of anterior laryngeal, 71 patients: Twenty-eight lived for five years or more and of these, 12 were free of symptoms. In other words, 16 still had symptoms after five years.

The author's treatment consisted of 180 KV., 4 ma.; focal distance, 40 cm., filter of tin; size of field, 6 by 8 cm., or more rarely, 8 by 10 cm., two lateral fields were used, with occasional anterior field; daily dosage, 300 Roentgens; total dosage, 6,000 to 7,000 Roentgens over a period of a month.

Two hundred thirty-eight laryngeal: 78 living after five years, 22 cured.

Thirty-seven hypopharyngeal: 12 living after five years, one cured.

The author concludes that he thinks Roentgen therapy should be the choice of treatment in this type of carcinoma. (As stated above, his classification is rather confusing, as well as origin of growth. The method of application is well worth trying out on definite types of inoperable carcinoma of the larynx. To fully evaluate the treatment of Roentgen therapy and surgery, a universal classification should be used.—H. B. O.)

ADENOCARCINOMA OF THE TRACHEA.

Pathological classification of assistance in treatment and prognosis — Dean[31] reports roughly one-half of the malignant tumors of the trachea are glandular in structure. Accurate pathological study is an aid to correct treatment and prognosis.

Mixed tumor and basal cell carcinoma, especially if found in the upper half of the trachea, should respond favorably to excision followed by irradiation therapy.

Adenocarcinoma (malignant adenoma) of the lower half of the trachea is invariably fatal. In the upper half of the trachea, cautery excision followed by irradiation, is the treatment of choice.

Two cases of fatal adenocarcinoma and one case of basal cell carcinoma with a good prognosis are presented.

BIBLIOGRAPHY.

1. Hauser, Maj. I. Jerome (Medical Corps, Army of the United States): The Practice of Otorhinolaryngology in an Army General Hospital. *Arch. Otolaryngol.*, 41:6:413, June, 1945.

2. Daggett, Brig. W. I. (London): Some Impressions of Otorhinolaryngology in Germany Today. *Jour. Laryngol. and Otol.*, LX:5, May, 1945.

3. Lumsden, R. B.: Injuries to the Larynx. *Jour. Laryngol. and Otol.*, LX:3:101, Mar., 1945.

4. Zinn, Waitman F.: The Significance of Hoarseness. *Ann. Otol., Rhinol. and Laryngol.*, LIV:1:136, Mar., 1945.

5. Smith, A. J.: Cancer of the Larynx. *Pa. Med. Jour.*, p. 258, Aug., 1932.

6. Greene, James S.: Speech and Voice Disorders Due to Oral and Laryngeal Defects. *Trans. Am. Acad. Ophthalmol. and Otolaryngol.*, p. 208, Mar.-Apr., 1945.

7. Gatewood, E. T.: A Simple and Practical Procedure for Developing Esophageal Voice in the Laryngectomized Patient. *Surg., Gynecol. and Obstet.*, 81:6:450, Dec., 1945.

8. Ross, Bernard D.: Five-Year Survey of Methods for Artificial Respiration. *Jour. A. M. A.*, 129:6:553, Oct. 6, 1945.

9. Gaines, Lt. Col. Thomas R., and Hatcher, Maj. Milford B. (Medical Corps, Army of the United States): Penicillin in the Treatment of Patients with Deep Infections of the Neck. *Arch. Otolaryngol.*, 42:1:1, July, 1945.

10. Loftus-Dale, H. W.: Anesthesia for Laryngofissure. *Jour. Laryngol. and Otol.*, London, LIX:11:434, Nov., 1944.

11. Murtagh, John A.: The Respiratory Function of the Larynx. Some Observations on Laryngeal Innervation. Preliminary Report. *Ann. Otol., Rhinol. and Laryngol.*, LIV:2:307, June, 1945.

12. Perlman, H. B.: Laryngeal Stroboscopy. *Ann. Otol., Rhinol. and Laryngol.*, LIV:1:159, Mar., 1945.

13. Baum, Harry L.: Treatment of Acute Laryngotracheobronchitis. *Arch. Otolaryngol.*, 41:3:175, Mar., 1945.

14. Otte, Jorge: Croup. *Rev. de Otorrinolaringol.*, IV:2:136, Sept., 1944.

15. Kennedy, J. M. (Sheffield): Laryngotracheal Diphtheria in an Adult Requiring Tracheotomy Complicated with Pregnancy, with Recovery. *Jour. Laryngol. and Otol.*, LIX:7:243, July, 1944.

16. Erich, John B.: The Treatment of Extensive Cicatricial Stenosis of the Larynx or Trachea. *Trans. Am. Acad. Ophthalmol. and Otolaryngol.*, p. 283, May-June, 1945.

17. Fox, J. R.: Paralysis of the Larynx; an Early Sign of Recurrence Following Radical Mastectomy for Carcinoma, with a Report of Six Cases. *Surg., Gynecol. and Obstet.*, 80:6:421, June, 1945.

18. Froeschels, Emil: Experiences of a Bloodless Treatment for Recurrent Paralysis. *Jour. Laryngol. and Otol.*, LIX:10:347, Oct., 1944.

19. Schall, LeRoy A.: Adaptations of Seven Charts on Cancer of the Larynx. *Ann. Otol., Rhinol. and Laryngol.*, LIV:1:174.

20. Snitman, Maurice F.: Carcinoma of the Larynx. Significance of Histopathological Study of Serial Sections; Preliminary Report. *Arch. Otolaryngol.*, 42:3:178, Sept., 1945.

21. JACKSON, C. L., and NORRIS, CHARLES M.: Surgical Treatment of Cancer of the Larynx. THE LARYNGOSCOPE, LV:5:196, May, 1945.

22. MCCALL, JULIUS W., and STOVER, W. G.: Laryngectomy for Laryngeal Cancer. Review of 45 Cases. THE LARYNGOSCOPE, LIV:12:659, Dec., 1944.

23. ROSEDALE, RAYMOND S.: Boeck's Sarcoid Involving the Face and the Larynx. *Arch. Otolaryngol.*, 42:4:281, Oct., 1945.

24. PATTERSON, NORMAN: Treatment of Carcinoma of the Vocal Lip by Operation. *Jour. Laryngol. and Otol.*, London, LIX:11:431, Nov., 1944.

25. GLICK, H. N.: An Unusual Neoplasm in the Larynx of a Child (Rhabdomyomyxosarcoma). *Ann. Otol., Rhinol. and Laryngol.*, LIII:4:699, Dec., 1944.

26. FOSTER, JOHN H.: Fibrosarcoma of the Larynx. *Ann. Otol., Rhinol. and Laryngol.*, LIII:4:764, Dec., 1944.

27. ARBUCKLE, M. F.; STUTSMAN, A. C., and MOORE, SHERWOOD: Treatment of Inoperable Cancer of the Throat; Follow-Up of Previous Report. *Ann. Otol., Rhinol. and Laryngol.*, LIII:4:689, Dec., 1944.

28. NIELSEN, J., and STRANDBERG, O.: Roentgen Treatment in Cancer of the Larynx. *Surg., Gynecol. and Obstet.*, 81:2:163, Aug., 1945.

29. WATSON, T. A., and LAMBERT, VICTOR: Results of Treatment of Carcinoma of the Larynx by X-ray at Operation. *Jour. Laryngol. and Otol.*, London, LX:4:174, Apr., 1945.

30. MUSTAKALLIO, S.: Carcinoma of the Larynx and Hypopharynx; Roentgen Treatment and the Results of Therapy. *Acta Radiol. Stoch.*, 25:13, 1944.

31. DEAN, LEE WALLACE, JR.: Adenocarcinoma of the Trachea. A Pathological Classification of Assistance in Treatment and Prognosis. *Ann. Otol., Rhinol. and Laryngol.*, LIII:4:669, Dec., 1944.

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AMERICAN BOARD OF OTOLARYNGOLOGY.

The next examination of the American Board of Otolaryngology will be held in Chicago at the Palmer House from May 22 to 25.

THE SELECTION OF HEARING AIDS.[1]

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PREFACE.

This is a report based on a program of work begun by the NDRC Aural Rehabilitation Project (17.3-19) operating under Directive AN-10. This project was broadly concerned with all electro-acoustic instruments and methods relevant to the rehabilitation of aural casualties. A major part of the general program has been an experimental study of hearing aids, both as physical instruments and as aids to hearing.

Their physical properties have been studied at the Electro-Acoustic Laboratory (formerly designated as Cruft Laboratory). These studies include an examination of the electrical circuits and the component parts of the instruments, their overall frequency responses, input-output characteristics for pure tones, harmonic distortion, battery drain, the acoustic properties of individual earmolds, and the body-baffle effect. Apparatus has also been developed for the determination of the optimum electroacoustic characteristics of hearing aids.

The Psycho-Acoustic Laboratory has been concerned with studies involving the transmission of speech by hearing aids,

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1. This research was initiated at the Psycho-Acoustic and Electro-Acoustic Laboratories of Harvard University under Contract OEMsr-658. This contract between the Office of Scientific Research and Development and Harvard University was supervised by NDRC Section 17.3. The work has been completed under Contract N5ori-76 between the Office of Research and Inventions, U. S. Navy, and Harvard University. Except for minor numerical changes based on recent experiments and for the omission of some historical material, this article is virtually a reprinting of report "PNR-7" issued by Psycho-Acoustic Laboratory, Harvard, dated 31, December 1945.

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4. Now at North Texas Agricultural College
5. Now at Bell Telephone Laboratories.
6. Now at Sanborn Co., Cambridge.
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the limitations they impose upon intelligibility, and the quality of their transmission. This laboratory has also developed several auditory tests that are useful for research on problems of impaired hearing, for the clinical diagnosis of hearing loss, and for the fitting of hearing aids. The problem of the optimum frequency characteristics for hearing aids has also been studied by means of the apparatus developed by the Electro-Acoustic Laboratory.

Another section of the project was concerned with the development and validation of diagnostic methods appropriate to impaired hearing. Central Institute for the Deaf, in St. Louis, has developed apparatus and methods of this type. Also, the tolerance limits for loud sounds have been determined for normal and for hard-of-hearing ears.

The work of these various laboratories was closely coordinated with the Aural Rehabilitation Services of the Army and the Navy. In particular, the NDRC project has endeavored to provide practical assistance in the design and procurement of acoustic facilities and equipment for several of the hospitals where the Aural Rehabilitation Services are located, and, through the Psycho-Acoustic Laboratory, the project has engaged in research programs which utilized the laboratory facilities at one of the Army hospitals. Through this association the special problems of military aural casualties and their rehabilitation have been studied, and the results of laboratory research at the Psycho-Acoustic Laboratory, at the Electro-Acoustic Laboratory, and at Central Institute for the Deaf have been validated and applied.

I – INTRODUCTION.

The present report undertakes a theoretical analysis of the general problem of "fitting" a hearing aid, and a critique of several present and proposed "fitting" procedures. New experimental data obtained at the Psycho-Acoustic Laboratory and at Central Institute for the Deaf as part of the general program are here summarized and form important parts of the foundation on which the general conclusions rest. It is expected that these data will be presented in full detail in

separate scientific publications in the near future. A point of view is developed which is quite at variance with the current thought and practice at the Aural Rehabilitation Hospitals, and with the preconceived ideas of the writers themselves. It is the unorthodox nature of the point of view and of some of our practical suggestions that justify the rather elaborate theoretical discussion.

II – SUMMARY.

Preliminary selection or "screening" of hearing aids on the basis of engineering specifications, to determine which of the available makes and models should be considered for "fitting," is both practical and desirable.

The differences between corresponding models of the leading manufacturers are relatively slight. Further improvement in performance is possible but it may not be very great. The direction of improvement is clearly indicated and the attainment is an engineering problem.

The appropriate frequency characteristic for a hearing aid is not correctly indicated by current principles of "audiogram fitting" or "selective amplification." A uniform frequency characteristic that can be varied by a tone control between "flat" and a moderate accentuation of high tones will provide the most satisfactory performance for all or nearly all cases of hearing loss.

Minor variations from the ideal frequency characteristic are relatively unimportant, but the maximum acoustic output must be chosen to suit the tolerance of each patient. Tolerance measurements must be made carefully, with due regard for psychological factors and the desirability of increasing tolerance gradually by experience. For the usual hard-of-hearing patient any detailed "fitting" is wasteful of time and effort. The differentials between instruments that are indicated by most current tests are largely illusory.

Routine test procedures should be designed to detect the unusual and difficult cases of hearing loss that require special attention. For such cases smaller differences between instru-

ments may be significant, and more elaborate selective tests are appropriate. The additional tests most likely to prove useful are those based on

1. the maximum (input) operating range;

2. the maximum articulation score on appropriate word lists; and

3. the minimum signal-to-noise ratio for intelligibility.

Such tests are unnecessary, however, for the majority of patients.

III – SELECTION AMONG EXISTING HEARING AIDS.

The immediate problem of the selection or "fitting" of a hearing aid is to select from among existing and available instruments the one which best "fits" the individual patient. There is also a closely related long-range problem of determining what ideal, nonexistent but possible instrument would best "fit" a given type of patient. This is the problem of design objectives, which is treated in Chapter IV, but both it and the immediate problem involve the important question of how to determine what is "best" for the hard-of-hearing patient. The problem proves to be extremely complex, and it appears impossible to provide an answer with quantitative exactness except for special or arbitrary conditions.

The Variety of Requirements.

The purpose of a hearing aid is to enable the hard-of-hearing subject to hear sounds that he cannot otherwise hear but desires to hear — particularly the human voice. It is the inability to understand speech that leads to practical difficulties and psychological maladjustments. We can, therefore, specify *"intelligibility of speech"* as the primary objective. Not all of the audible frequencies are required for perfect understanding of speech, and the necessary frequency range of a hearing aid can be narrowed accordingly.

The technique of testing the intelligibility of speech by means of word lists or sentences (articulation scores) is well established. But if, as would be logical, we undertake to base our choice on articulation scores, we must recall that the artic-

ulation score (intelligibility) varies with loudness and the loudness must, therefore, be specified in some way. The difficulty of making this specification and the related specification of the setting of the gain control of the instrument is elaborated in a later section. Likewise, intelligibility is a function of the particular words (or sentences) used for the test. Different lists may, deliberately or accidentally, be chosen to emphasize particular phonetic elements. Definite methods of testing and of selecting test material must be adopted. The test becomes either unwieldy if large samples of speech are used, or arbitrary if only a small sample is employed.

After the test material has been selected a talker must be chosen. Is the voice to be that of a man or of a woman? And how many voices and what dialects should be used? One instrument may give better intelligibility for a man's voice, another for a woman's. If many voices are tested the procedure again tends to become unwieldy.

The same considerations apply to the acoustic environment in which the tests are to be conducted. Should all tests be performed in the quiet? Should the room be reverberant? If a background of noise is desired in order to approximate usual conditions then what noise is to be chosen, and how loud should it be?

This variety of voices, voice levels, speech sounds, and acoustic environment introduces great complexity into the apparently simple criterion of "intelligibility of speech." Comparisons obtained under any arbitrary set of conditions are strictly valid only for those special conditions, and they become more and more uncertain as they are extrapolated or generalized to other conditions.

In addition to the primary requirement of intelligibility of speech there are a number of secondary requirements for a "good" hearing aid. Many of these secondary requirements are most clearly expressed in negative form. For example, a hearing aid must make speech intelligible without making it uncomfortably loud. The instrument must not be too expensive, too heavy, too unsightly, or too uncomfortable to wear, and it must be reasonably durable and reliable. Repair serv-

ice and/or replacement service and a supply of proper batteries must be reasonably available. Finally, the patient usually desires a pleasing or "natural" quality in the sound of voice and music. Unfortunately the "quality" preferred by the patient is not always compatible with the greatest intelligibility, but with respect to the other secondary requirements the patient's personal opinions are the chief criteria.

The Variety of Auditory Impairments.

If we consider the general problem of what is the ideal hearing aid, in order to lay down design objectives or to write minimum specifications, we are faced by a variety of impairments of auditory function. The details of the requirements vary from patient to patient. All hard-of-hearing patients (by definition) require more acoustic energy, whether it is to be provided by a raised voice, a cupped hand, an ear trumpet, or an electronic amplifier. But a patient's loss of sensitivity is not necessarily uniform as a function of frequency. Many patients become quite deaf to high-frequency sounds but still hear sounds of low frequency quite well. A smaller number suffer from a (relative) low-tone deafness, while for a few it is the sensitivity to tones in the middle of the audible range that is most impaired. A very common type of hearing loss is one that is moderate for low and middle tones and severe or total for high-pitched sounds.

We shall point out that this difference from one patient to another is overemphasized by audiometric measurements. Even so, the differences in degree of overall impairment (as measured by an average audiogram or by the elevation of the threshold for speech), in the distribution of the impairment with respect to frequency, and in the thresholds of pain and discomfort are so great that any single rigid set of specifications for the design of a hearing aid is arbitrary.

Practical problems of diagnosis, which may have an important bearing on the prognosis of the benefit to be expected from a hearing aid, appear in some cases in the form of pitch distortion, known as "diplacusis." In this condition pure tones are heard as noises, or as complex tones, or as tones of abnormal pitch. The distortion may be confined to part of the

auditory frequency range. No hearing aid can correct this disability, and the defect is not necessarily revealed by simple audiometry or casual questioning.

Other defects of "hearing" that do not depend on abnormalities of the ear, and which are helped little or not at all by a hearing aid, include the hearing losses that are due to abnormalities of the central nervous systems. Tumors, skull fractures, arteriosclerosis, etc., may encroach on the auditory system. Certain cortical lesions may cause a loss of the understanding of words ("word deafness") even though pure tones and noises may be heard with normal acuity. And conscious or unconscious motivation may confuse the clinical picture by introducing various combinations of malingering and "hysterical" deafness. Either or both of the latter complications may be combined with a peripheral hearing loss in the ordinary sense of the word. The complications are mentioned here not because hearing aids are of much assistance in such situations, but merely to emphasize the complexity of the total clinical picture of "impairment of auditory function." Some of the rare but genuine cases of extraordinary benefits from one hearing aid after complete failure with another are more comprehensible if psychosomatic and psychological factors are considered in addition to the purely physical and physiological.

A totally different type of complication is a local condition, such as a chronically discharging middle ear or a deformed ear canal resulting from an unsuccessful fenestration operation, or an unusual tenderness of skin or mucosa that limits the use of a conventional molded earpiece. The employment of a bone-conduction receiver may be obligatory in such cases. This may or may not be a serious limitation in any individual case, but the present trend of opinion seems to favor the use of air conduction when possible as offering better fidelity and a greater range of power output.

The Variety of Present Instruments.

The problem for the individual patient is to choose among the great number of available makes and models of hearing

aids. New makes continually appear on the market, and each manufacturer usually offers a choice among several models (including in some cases the carbon type as well as vacuum-tube instruments), and an additional choice among two to six or eight earphones.

Some practical restriction of the field of inquiry, both for the patient who wishes to buy and for the investigator who wishes to experiment, is obviously desirable. The American Medical Association's Council on Physical Medicine has undertaken for a number of years to provide just such a preliminary selection by either approving or disapproving hearing aids submitted to it by manufacturers. Disapproval may be based on any obvious shortcomings in engineering construction or in acoustic performance. The tests employed, as described in reports in the *Journal of the American Medical Association,* are realistic but not elaborate. In some cases, however, the approval of the Council has been withheld because of the advertising policies of the manufacturers and not because of any defects of the instrument. There may also be an unavoidable delay following the introduction on the market of a new make or model while the report of the Council is in preparation, so that lack of Council approval does not necessarily mean that an instrument is physically defective or inadequate.

The NDRC project dealing with instrumental aids to hearing, when it undertook to determine the electro-acoustic and the performance characteristics of hearing aids, limited its study to the products of those manufacturers whose instruments had been approved by the Council on Physical Medicine as of the year 1944. Seventeen vacuum-tube instruments and three carbon-microphone instruments were examined, and it is believed that these represent an adequate sample of available aids. Both the individual patient and the hearing-aid consultant may usefully, although not necessarily, restrict their field of choice in the same way.

One justification of such a practical restriction of choice lies in the basic similarity of existing hearing aids. There are

countless minor differences, but all instruments examined are enough alike to make it doubtful whether any of the unapproved instruments provide any great advantages based on radical differences in design. All approved hearing aids consist of a microphone, an amplifier, and an earphone. For low and medium input levels the output is proportional to the input (linear amplification), and the amount of gain is regulated by the gain or volume control. The maximum acoustic output of a hearing aid is definitely limited, usually by the power capacity of the final stage of the amplifier. All instruments introduce a considerable degree of frequency distortion, *i.e.*, they amplify some frequencies to a greater extent than others. Usually a band an octave or an octave and a half in width and beginning a little above 1,000 c.p.s. is more efficiently amplified than the octave next below, while below about 500 c.p.s. and above about 2,500 c.p.s. the amplification of most instruments falls off sharply. (There is considerable variation in the details of smoothness and contour of the frequency responses from model to model and with different settings of the tone controls, and a few instruments have somewhat wider bands of effective amplification.) Not much harmonic distortion is present in any of them until high input levels are reached, and then this type of distortion becomes considerable, particularly for frequencies between 250 and 1,000 c.p.s. All the powerful instruments are subject to "squeal" from acoustic feedback if they are used at high gain with a poorly fitting earpiece.

There are a large number of measurable but independent physical characteristics, and actual hearing aids present a multitude of permutations and combinations of the exact numerical values of these characteristics.

On the other hand, the practical significance of this variety of differences in detail is difficult to evaluate, for subjective differences and differences in performance are not always clearly related to the physical characteristics that are measured. For example, "poor quality" or a low articulation score may be due to a very irregular frequency response, to harmonic distortion, to acoustic or even electrical feedback, or

to inherent electrical noise. And sometimes differences which are fairly easily measured, such as sharp dips in the frequency-response characteristic, seem to make less difference under conditions of actual use than might be expected. The "quality" may be judged slightly imperfect, but this difference is difficult to measure. Intelligibility (articulation score) is not likely to be much impaired unless the quality is very poor. The listener is not directly aware of irregularities in the frequency characteristic. There is a strong psychological tendency to "fill in the gaps," and also to accept a considerable degree of distortion as naturally as we accept the acoustic imperfections of our ordinary surroundings, with their resonances, absorption, echoes, and ambient noises. The essence of hearing is to discriminate the desired pattern, whether speech or music, from the background, and to recognize it as a meaningful pattern. A part of the pattern may be nearly as effective as the whole for purposes of recognition, and a considerable degree of distortion is easily tolerated even by many hard-of-hearing ears.

The problem of selection among existing instruments is complex, therefore, not only because of 1. the variety of the requirements of a hearing aid, and 2. the variety of individual auditory impairments, but also because of 3. the variety of existing instruments. The situation is helped somewhat by our knowledge of certain general physical similarities among commercial hearing aids, but there is still a great variety of differences in physical detail, and *we are uncertain of the significance of these measured differences in terms of the actual performance of the instruments.*

Practical Approach to the Problem of Selection.

From the foregoing discussion it should be clear that it is impossible to base the selection of hearing aids on any single or composite "figure of merit" derived from purely physical measurements. No single physical characteristic is sufficiently all-important to be made the basis of such a "figure of merit," and it is unlikely that any constant or workable formula for combining the values of several characteristics can be found. The relative importance of various characteristics

varies too greatly from patient to patient, and even when physical measurements have been made their evaluation is still uncertain. For example, some acoustic gain is essential, more is better, but too much becomes intolerable.

The principle of minimum specifications followed by the Council on Physical Medicine is only a partial solution. The principle is to approve and to consider for selection only those instruments which are up to a reasonable standard in terms of the general state of the art. It insures that certain negative requirements that are important for all users will be met. The approved instruments will all be well constructed, free from excessive internal noise, and capable of providing a useful amount of amplification. Every hearing-aid consultant or Rehabilitation Service probably has his or its own, usually informal, list of "approved" instruments, which may or may not be identical with the list of the Council on Physical Medicine. But such a preliminary screening does not solve the problem of selection among the approved instruments.

The Necessity of Compromises.

In the design and construction of hearing aids certain engineering compromises are unavoidable. The obviously desirable features of light weight and low cost are directly opposed to the objectives of high fidelity, high amplification, adequate power output, and long battery life. The variety of available instruments is actually a variety of different compromises that have been achieved and are offered for choice.

Another type of compromise that is equally important but less frequently recognized is based on the *physiological limitations of a defective ear.* The threshold of a hard-of-hearing ear is elevated. An ear is not ordinarily considered sufficiently hard of hearing to require a hearing aid unless the loss of sensitivity (elevation of threshold) for speech is at least 30 db., and the loss may be 70 db. or more. But with elevation of threshold there is seldom (if ever) a corresponding increase in tolerance for loud sounds. Experimental data summarized in a later section show that the average thresholds of discomfort, tickle, and pain of hard-of-hearing ears

are almost identical with the same thresholds of tolerance for normal ears. There is a physiological limit, therefore, to the maximum acoustic power which hearing aids should be designed to deliver. And even for the ears that can tolerate and might profitably use greater acoustic power, a practical limit is likely to be set by acoustic feedback. The most powerful present instruments require very well fitted earpieces in order to utilize their full power. The result is that the "dynamic range" of the ear, *i.e.*, the number of decibels of intensity between threshold and the limit of tolerance, is reduced. Complete compensation for the hearing loss, even by the most perfect amplification of sound, is theoretically impossible. The necessary limitation of maximum output unavoidably involves a certain amount of acoustic distortion. The engineering compromise between wide dynamic range and unavoidable distortion may be more or less successful, but some compromise short of perfection must be accepted by the patient.

Practical Principles of Compromise.

The first principle of compromise is to insure adequacy in essentials. Certain first-order requirements must be met before second-order objectives or third-order considerations become significant. The following obvious essentials may be listed:

1. *Power.* The hearing aid must produce sufficient acoustic power (at full gain setting and with loud input speech if necessary) to override the patient's deafness and make some sounds audible. This minimum performance may be the best that can be done for patients who are almost totally deaf. Even slight auditory cues may be helpful, but if nothing is heard the instrument is obviously useless.

2. *Tolerability.* Audibility (and intelligibility if possible) must be obtained without pain, tickle, or serious discomfort.

3. *Fidelity.* If the patient's ear is at all capable of hearing a sufficient band of frequencies, and his brain is capable of interpreting them, then a hearing aid should render intelligi-

ble to him simple connected speech that is clearly and loudly spoken.

4. Wearability. The earpiece must be tolerable to wear, and the instrument as a whole must be portable without unreasonable discomfort and inconvenience.

5. Sensitivity and amplification. It is highly desirable, although not absolutely essential, that the instrument render intelligible any ordinary speech that is delivered to it at conversational levels. It is *not* important, however, for the instrument to restore normal auditory acuity. Not only is this objective often very difficult or impossible to achieve, but it is a luxury, since speech at the normal threshold level (in quiet) is masked by ambient noise in all practical situations.

The last item in this list of essentials merges into the *second-order objectives,* which may be summarized as the efforts *to increase the range and versatility of adequate performance.*

1. Complete tolerability. The *maximum* acoustic output that the instrument can produce must not cause pain or serious discomfort.

2. A wide dynamic range of speech input. The patient should not be forced to adjust the gain control continually to maintain audibility while avoiding distortion. This is especially important in situations involving group conversation.

3. Increased intelligibility. A word-articulation score of 90 per cent is a reasonable objective for a patient who is definitely but not extremely hard of hearing. Perfection is impossible for many ears.

4. A wide range of voices and of listening conditions. A variable tone control, allowing a change of the degree of suppression of low tones, is useful in obtaining this additional versatility.

5. Durability, reliability, and long battery life. These considerations are obvious.

The second-order objectives merge in their turn into the

third-order considerations. It is obviously desirable to make speech (and music) pleasing in quality if intelligibility does not suffer thereby. Internal noise, whether electrical or mechanical in origin, should be reduced below the patient's threshold. Perfect articulation and an extreme range of sensitivity are desirable if the price (in dollars or in other compromises) is not too high. Lightness, esthetic appearance, mechanical convenience, size, availability of batteries, and, finally, cost and problems of service, repair, or replacement: all of these considerations fall in this category.

The Law of Diminishing Returns.

It is quite impossible to lay down rules for evaluating the importance of these various features. A feature that is usually unimportant because it is adequately provided by all instruments, such as battery life or mechanical durability, suddenly becomes important if the instrument falls below the average standard. (The preliminary screening on the basis of minimum specifications, already discussed, is intended to minimize this difficulty). At the other extreme, a fairly high level of performance in dynamic range, in sensitivity, or in articulation is very important, but as the theoretical limits of performance are approached the practical importance of further improvement diminishes. Perfection becomes a luxury.

Incommensurable Variables.

Even if we should succeed in assigning numerical values for performance or other characteristics (as for articulation scores, for dynamic range, for weight, and for price) and even if the values are adjusted to meet the difficulty pointed out in the preceding paragraph, there is still no rule for comparing one feature of performance with another. The crux of this difficulty lies in the different requirements of different patients and the subjective judgment of the relative importance of widely different considerations. A consultant or "fitter" can advise, but for many questions, notably comfort and the esthetic and economic considerations, the patient is the only judge.

Uncertainty of Measurement.

A final difficulty in evaluating the considerations on which the selection of a hearing aid is to be based lies in the uncertainty of measurement. In the face of imponderables such as a patient's preferences regarding quality or mechanical convenience, there is a strong tendency to decide the issue on the basis of any advantage, however slight, that may appear in whatever quantitative comparisons are made. *A difference of a point or two in an articulation score, or of two or three decibels in a threshold test or in a signal-to-noise ratio, is often stressd far beyond its real significance.* The reliability of the result of a single test on a patient, particularly on one who is unaccustomed to the test procedures, is usually quite low, and small differences in the numerical values are more likely to be due to chance factors than to any real advantage of one instrument over another. To base decisions on small differences that are in fact unreliable is to create an illusion of accuracy and a pseudoscientific basis of selection.

All the principles of compromise and all the difficulties in making a definite selection are quite familiar to those who have been faced with the responsibility for such selection. They are recognized implicitly, and quite correctly, in statements that "the experience and clinical judgment of the fitter are of great importance," and that "selection should not be based on the results of a single test but on a consideration of the total picture." In fact, the chief justification for the foregoing enumeration of obvious propositions is to emphasize the importance of experienced judgment in evaluating imponderables and comparing incommensurable values.

The Inadequacy of the Classical Solution.

So far no specific reference has been made to the principle of "selective amplification" which has been widely accepted, implicitly or explicitly, as a guide to the selection of the "best" hearing aid for a patient. The classical argument runs somewhat as follows: It is agreed that a hearing aid must be durable, wearable, and tolerable, and that it should make speech intelligible. As a rule several models and several com-

binations of tone-control settings and earphones meet these primary criteria and the problem is to choose among them. The instruments are known to differ, particularly with respect to their frequency responses. Some emphasize high tones more than others, and some amplify a wider band of frequencies than others. Patients also differ in their hearing losses, as shown by differences in their audiograms. It is "obvious" that the instrument which restores the patient's audiogram most nearly to normal is the "best" instrument for that patient.

The principle of restoring the audiogram to normal by "selective amplification" is applied in two ways: *1.* it is used as a guide in selecting the particular earphone or tone-control setting (high-tone emphasis, low-tone emphasis, etc.) which is most likely to be useful to the patient. *2.* It is also made the basis of a specific test, the so-called "aided audiogram," to determine which instrument best "fits" the patient. The method is often compared to the fitting of eyeglasses to correct defects of vision.

Shortcomings of "Audiogram Fitting."

The theoretical objections to and the practical difficulties involved in "audiogram fitting" may be summarized briefly:

The audiogram reveals the threshold of auditory sensitivity; but listening is usually done, by choice, well above the threshold level. It may be assumed that, except for very severe hearing loss, the hearing aid provides sufficient gain to deliver speech at the "comfort" level well above threshold. It is also known that almost invariably the upper portions of the auditory area are less abnormal, less distorted, and less irregular than is the threshold. The "equal-loudness contours" tend to be more nearly regular and horizontal than the threshold, particularly in the range of frequencies important for speech. In other words, the loudness of tones of equal physical intensity is much more uniform well above threshold than near threshold, whether the listening ear is defective or normal. Watson and Knudsen* have suggested accordingly

*Watson, N. A., and Knudsen, V. O.: Selective Amplifiction in Hearing Aids. Jour. Acous. Soc. Am., 11:406-416, 1940.

that it is an equal-loudness contour at the level of comfortable listening that should be fitted, not the threshold.

Unfortunately, it is impractical to determine equal-loudness contours by loudness matching as a routine procedure with untrained patients. The attempt was made at Deshon General Hospital as part of the present project, and the determinations proved to be either unreliable or unduly time-consuming.

The frequency characteristics of hearing aids are, as a rule, rather irregular. Therefore, even if an audiogram or an equal-loudness contour is known with greater precision than is afforded by the customary sampling at octave intervals, it is usually impossible to obtain anything better than a very approximate compensatory "fit." Furthermore, the frequency characteristic of a hearing aid as used near its maximum output differs from its characteristic at moderate output levels.

Although the frequency characteristics of many hearing aids have been determined, using free-field input and measurements of output in a closed coupler, there are uncertainties as to the frequency characteristics of the instrument as actually worn, owing to the familiar body-baffle effect and (variable) leakage around the molded earpiece. The matter is further complicated by resonances within the ear canal.

These difficulties can be met, in theory, by determining the "aided audiogram" of the patient actually wearing the hearing aid under test. In order to avoid technical errors due to standing waves in the test chamber, however, this procedure requires a test room of special acoustic properties, or rigid control of the position of both patient and hearing aid. Even under ideal conditions the procedure is subject to the uncertainties and relatively low reliability of all tests conducted with untrained subjects. If adequate reliability is obtained by repeated tests the procedure becomes too unwieldy and time-consuming for routine "fitting." And even if all practical and technical difficulties are overcome the important theoretical difficulties noted above still remain.

Experimental Disproof of the Principle of "Selective Amplification."

In a later section will be summarized the findings of a series of experiments recently completed at the Psycho-Acoustic Laboratory. For 25 hard-of-hearing ears, the relative value of several widely different patterns of frequency response was obtained by means of the so-called "Master Hearing Aid." The patterns which yielded the best results were found to bear very little relation either to the subject's audiogram or to an equal-loudness contour. Even if the audiogram was used only as a general guide to determine whether or not additional amplification should be provided for high frequencies, it proved actually misleading in several instances. On the other hand, a particular set of frequency-response patterns proved uniformly successful for all ears tested. These results, definitely contrary to the original expectations of experimenters, seem to show that *it is possible to specify the desirable frequency characteristics of a hearing aid more successfully by a simple general rule than by any interpretation of the patient's audiogram.*

Other Methods of Fitting.

In a later section will be found a description and critique of several other methods and test procedures that have been tried or suggested to determine objectively which of several hearing aids is "best" for a patient. All the methods accept the audiogram as a general guide in the preliminary selection and then endeavor to measure differences in the performance of the patient as he wears the various instruments. Nearly all the selective tests make one or another of the following attempts:

1. To measure the dynamic range provided by the instrument, *i.e.*, the difference in decibels between the threshold of intelligibility for speech and some upper limit, usually the threshold of tolerance for speech.

2. To measure articulation scores, *i.e.*, the ability to identify words or understand sentences correctly.

3. To introduce some additional special difficulty, such as

background noise, in an effort to make articulation tests more discriminating.

In Chapter V it will be pointed out that some of the tests are useful in special cases, but, because of the variety of requirements for a hearing aid and the general similarities among existing instruments, and because the tests are usually arbitrary in their conditions, they are of little real value for discriminating between instruments as worn by the majority of patients.

Summary: It is our opinion that:

1. A general preliminary selection or "screening" based on engineering principles is possible, and such screening is desirable to eliminate obviously inferior instruments.

2. The patient's audiogram is often misleading as a guide to the selection of a hearing aid. Experimental evidence seems to show that the principle of "selective amplification" to compensate for impairment of hearing is fallacious.

3. Individual detailed "fitting" is futile and illusory because of the variety of requirements to be met and the difficulty of evaluating the variables between which it is necessary to compromise. Reliable discrimination between instruments by objective tests is achieved in only a minority of cases. The tests are either too arbitrary (confined to special conditions and requirements), too elaborate (impractical), or inconclusive (statistically unreliable).

IV – SPECIFICATIONS AND DESIGN OBJECTIVES FOR HEARING AIDS.

One of the objectives of the NDRC project on Instrumental Aids to Hearing has been the long-range problem of determining the design objectives for hearing aids which manufacturers should ultimately seek to attain. It is obvious that the basic problem of measuring the performance of experimental models of hearing aids is the same as the problem of "fitting" the individual patient. But in dealing with the problem in general terms there is the great advantage that it is practical to select a group of hard-of-hearing sub-

jects, to train them as observers, and with them to conduct elaborate systematic experiments (such as the establishment of equal-loudness contours and of complete articulation functions) that are out of the question for individual routine "fitting" because of considerations of space, time, and equipment. The systematic experiment serves to establish general principles on the basis of which specifications may reasonably be drawn.

Program of the NDRC Hearing-Aid Project.

After the characterisics of existing hearing aids had been determined, the Electro-Acoustic Laboratory, the Psycho-Acoustic Laboratory, and Central Institute for the Deaf undertook to explore quantitatively with hard-of-hearing subjects the problems of tolerance, of articulation, and of other aspects of auditory function that were already fairly well known for normal subjects. Some exploratory tests were conducted at Deshon General Hospital, but most of the work was done at Central Institute for the Deaf and at the Psycho-Acoustic Laboratory where special electro-acoustic instruments and small but stable and trained teams of representative hard-of-hearing subjects could be assembled.

On the basis of the data obtained in these experiments, the experience gained through NDRC work at Deshon General Hospital, and the exchange of information with the other Aural Rehabilitation Services of the Army and the Navy, the tentative specifications and quantitative design objectives presented in this chapter were drawn up. It was then realized that a single versatile instrument of appropriate general characteristics, with a variable tone control and a semipermanent adjustment of maximum acoustic output could encompass the entire range of the specifications.

Until instruments based on these specifications are generally available, the specifications may serve usefully as a guide in the selection of hearing aids on the basis of their known electro-acoustic characteristics.

Summary of Recent Experimentation by the NRDC "Hearing-Aid Projects."

Equal-Loudness Contours (Deshon General Hospital, Central Institute for the Deaf, Psycho-Acoustic Laboratory).

The determination of equal-loudness contours by simple monaural matching of pure tones for equal loudness was attempted with military patients at Deshon General Hospital and with civilian patients at Central Institute for the Deaf (CID). The subjects were hard of hearing, and, except for a few of those tested at CID, none had any previous experience in auditory testing other than routine audiometry. The results of the first several attempts of each patient to equate for loudness the two tones of different pitch were disappointingly erratic, and some of the less intelligent military patients were unable to grasp the concept satisfactorily even after several trials. It was concluded independently by both groups of investigators that the method, although of value for auditory research with selected and experienced subjects, was not suited to routine clinical testing.

At Psycho-Acoustic Laboratory at least one equal-loudness contour was obtained for most of the hard-of-hearing subjects employed in a series of articulation tests. With these subjects by patient repetition of tests fairly satisfactory contours were obtained. The results confirm the prevalent view that equal-loudness contours that lie well above threshold are relatively normal except in cases of severe high-tone hearing loss.

Thresholds of Tolerance: Discomfort, Tickle, and Pain (Central Institute for the Deaf).

The thresholds of *discomfort*, of *tickle*, and of *pain* produced by pure tones and by speech were determined in over 11,000 observations, on 46 normal and 46 hard-of-hearing ears.

The initial thresholds for pure tones of pain and of tickle lie at about 140 db. and 133 db., respectively, for all frequencies from 250 to 5 600 c.p.s. The median intensities are greater for the normal group than for the hard-of-hearing group

owing to the presence of more "tender" hard-of-hearing individuals reporting tickle and sometimes pain between 120 db. and 130 db.

The threshold of discomfort approximates an equal-loudness contour, and shows a broad minimum (3 db. below the mean) between 1,400 and 4,000 c.p.s. The initial median threshold for the normal (110 db.) lies below the threshold for the hard-of-hearing (120 db.), but there is great dispersion, particularly among the hard-of-hearing.

Similar determinations made with carefully monitored (recorded) speech gave a similar set of values, tabulated below. Tickle is a more constant phenomenon for speech than for pure tones, and has a lower threshold as measured by a VU meter; but pure tones cause discomfort at lower thresholds in normal ears than does speech.

All three thresholds rise systematically and significantly with successive test sessions either daily or weekly, and approach limiting values after several test sessions. Preliminary median values in decibels re .0002 dyne/cm^2 are tabulated below.

	Discomfort		Tickle		Pain	
	Initial	Final	Initial	Final	Initial	Final
NORMAL						
Pure Tone	110	120	133	(>142)	140	(>142)
Speech	117	130	129	135	138	(>139)
HARD OF HEARING						
Pure Tone	118	129	129	(>141)	136	(>141)
Speech	121	130	129	134	135	(>137)

The values are median intensities for the various groups of experimental subjects. The figures in parentheses indicate the limits of the apparatus for that particular test, and the notation (>141), etc., indicates that the threshold for more than half of the subjects was above 141 db. (r.m.s.) re 0.0002 dyne/cm.^{2} The values in this table have been modified slightly from those given in report PNR-7 on 31 December 1945 as the result of additional tests and recalculations of the data.

The increased tolerance is largely but not entirely retained after an interval of a week, and about half of the increase is retained for at least 20 weeks without additional exposures.

Development of tolerance for speech elevates slightly the tolerance thresholds for pure tones. Pure tones are less effec-

tive in elevating the tolerance thresholds for speech. Development of tolerance for speech or for pure tones in one ear does not increase the corresponding tolerance of the other ear of the same individual.

Tolerance may be developed effectively by exposure to loud speech at a level just below the threshold of discomfort for several minutes a day on three or four successive days.

Optimum Tilts and Limits of the Frequency Spectrum (Electro-Acoustic Laboratory, Psycho-Acoustic Laboratory).

The "Master Hearing Aid" was designed and constructed at the Electro-Acoustic Laboratory. This instrument offers the choice of five simple frequency characteristics clearly distinct from one another. Its basic frequency characteristic (acoustic gain as a function of frequency) is flat within ± 3 db. from 100 to 3,000 c.p.s.; above this point the properties of the earphone cause the overall range of variation to be about ± 5 db. between 100 and 7,000 c.p.s. The frequency spectrum can be limited by high-pass and low-pass filters that cut off, with a slope of 17 db. per octave, at the following nominal cutoff frequencies: 100, 250, 500, 1,000, 2,000, 3,000, 4,000, and 5,000 c.p.s.

Four "tilted" frequency characteristics are provided. One of them rises uniformly at 6 db. per octave from 100 c.p.s. to 7,000 c.p.s. It is designated as "high pass 6 db. per octave." Another characteristic rises at 12 db. per octave. The third and fourth give corresponding low-tone emphasis with slopes of 6 and 12 db. per octave, respectively.

The maximum acoustic output is normally limited by the power-handling capacity of the output stage of the amplifier. The result is rather sharp "peak clipping" at 150 db. peak instantaneous acoustic output, measured as pressure re .0002 dyne/cm^2 developed by the PDR-10 earphone in a 6 cc. coupler. (This level corresponds to 147 db. r.m.s undistorted acoustic output.) Provision is also made for limitation by peak clipping at the lower levels of 134, 124, 114* db. maximum instantaneous acoustic output.

*These levels were erroneously given as 139, 128, and 118 db., respectively, in report PNR-7.

At the Psycho-Acoustic Laboratory tests have been conducted with this Master Hearing Aid on a carefully selected group of 25 hard-of-hearing subjects (including three military aural casualties) with moderate to severe hearing losses of the various clinical types. Some, but not all, of the subjects habitually use hearing aids. Articulation scores were obtained at various gain settings of the amplifier with all of the frequency characteristics that gave a significant degree of intelligibility. The maximum output was ordinarily limited to 124 db. peak instantaneous acoustic pressure, but the effects of higher and lower limits were briefly explored. The usual frequency range employed was 100 or 250 to 7,000 c.p.s., but the effects of wider and narrower limits were also investigated. Supplementary tests of quality comparisons, of the threshold of intelligibility for speech, and of signal-to-noise ratios were also conducted. (In fact, the articulation scores of several of the subjects were so high with the Master Hearing Aid that it was necessary, with these subjects, to introduce a constant level of background noise mixed with the input speech in order to discriminate the relative advantages of the various settings of the Master Hearing Aid.)

Two criteria of performance were employed. One was the articulation score obtained at the optimum gain setting, using the "PB" (phonetically balanced) word lists* of the Psycho-Acoustic Laboratory. The other was the operating range, *i.e.*, the range of gain setting for which the articulation scores exceeded 50 per cent. (The 50 per cent articulation level for the PB lists is one at which the gist of ordinary connected discourse is easily understood.) The setting of the Master Hearing Aid which gave the best performance by one criterion usually, although not necessarily, gave the best or nearly the best performance by the other also.

All but one subject tolerated and even preferred the maximum acoustic output level at 124 db. rather than at 114 db. The exceptional subject tolerated the 124 db. level after a few trials. Only one subject of the 20 preferred the highest limiting level of 134 db.

*cf. Chapter V.

For every subject the best performance could be obtained by using either the "flat" system or the high-pass 6-db.-per-octave tilt. In several cases the two sets of results were indistinguishable. The subjects with severe hearing losses that included the high tones tended as a group (although not for every individual) to do a little better with the high-pass 6 db. characteristic. Those with "flat" losses did better with the flat characteristic. For two subjects with low-tone hearing loss the flat and the low-pass 6 db. tilt were about equally effective.

Tests of restricting the frequency range were conducted only with the "flat" frequency characteristic. Setting the upper frequency limit at 4,000 c.p.s. instead of 7,000 c.p.s did not cause any significant impairment of performance for any subject as tested. Setting the lower limit at 500 c.p.s. instead of at 100 or 250 c.p.s. gave better results for five of the seven subjects so tested, and for the other two, who both had low-tone hearing loss, the results were just as good as with the more extended low-tone range. But restriction of the range to the single octave between 1,000 c.p.s. and 2,000 c.p.s. impaired the performance for eight out of nine ears.

The "quality" of either the flat or the high-pass 6-db.-per-octave characteristic (or both) was judged by some but not all of the hearing-aid users as about equal to or better than the quality of their own instruments. Their articulation scores were invariably as good or better with the Master Hearing Aid. There was no clear indication of any benefit of the special frequency characteristics of their own instruments, even with the advantage of familiarity.

A few (five) experiments with a combined frequency characteristic, flat from 250 to 1,000 c.p.s. and rising at 6 db. per octave from 1,000 to 4,000 c.p.s., failed to show any significant advantage or disadvantage for this combination with respect to the simple flat or high-pass 6 db. patterns.

Limitation of the maximum acoustic output by compression amplification instead of by simple peak clipping served to increase the operating range significantly for most of the

subjects tested, and in several cases to increase the optimum articulation score as well.

Tentative Specifications for Hearing Aids.

The results of the foregoing experiments and the opinions of the members of the NDRC Hearing-Aid Projects are the basis of the following list of specifications and suggestions for hearing-aid design. Emphasis has been placed on ideal design objectives rather than on minimum specifications; but in several instances specific minimium requirements are proposed. While it is believed that the specifications can now be achieved, no effort has been made to make the phraseology completely rigorous or the list exhaustive. Some interpretative comment is also included.

1. Frequency Characteristic: Range.

The overall acoustic frequency characteristic of a hearing aid should be uniform (*i.e.*, without sharp peaks or valleys) between a lower cutoff frequency not higher than 400 c.p.s. or lower than 200 c.p.s. (and preferably at 300 c.p.s.) and an upper cutoff frequency not lower than 3,000 c.p.s. (and preferably at 4,000 c.p.s.). The response contour should be smooth at the maximum power-output level as well as at ordinary operating levels. The high-frequency cutoff can be as abrupt as engineering convenience requires. Below 200 c.p.s. the frequency response should fall off at a rate of at least 10 db. per octave, and a sharper cutoff is permissible.

a. The desirability of avoiding resonant "peaks" and "valleys" is considered obvious, but no data are available on which to base a minimum requirement of uniformity.

b. There are positive advantages in the cutoffs at 300 c.p.s. and 4,000 c.p.s., in addition to engineering difficulties in providing wider ranges.

1. Frequencies above 4,000 c.p.s. add little to the intelligibility of speech even for normal listeners. Most hard-of-hearing patients are so deaf to frequencies above 4,000 c.p.s. that these higher frequencies cannot be heard at any comfortable level. Many who

do hear them are greatly annoyed by sounds containing them, which detracts from any usefulness they might have.

2. Low tones, whether speech or noise, when amplified to high levels gain disproportionately in loudness, owing to the shape of the equal-loudness contours. The result is an unpleasant "booming" quality. Low pitched components of ambient noise or of a background of mixed conversation, when amplified to high levels, mask higher-pitched components of speech.

3. An imperfectly fitting or leaky earpiece will cause attenuation for frequencies below 300 c.p.s., but this method of producing low-tone attenuation is undesirable because of the danger of acoustic feedback.

2. Frequency Characteristic: Slope.

Between the cutoff frequencies of about 300 and 4,000 c.p.s. the overall slope of the frequency characteristic should be "flat" or should rise toward the high frequencies with a slope of not more than 1 db. per octave. An adjustable tone-control should provide an alternative slope, rising evenly toward the high frequencies at between 6 and 7 db. per octave. These two extreme adjustments are required. At least one intermediate setting or a continuously variable tone control is recommended.

a. An instrument with a tone control which can be readily switched by the wearer is preferable to separate models with different fixed frequency characteristics, because:

1. If both extremes are available in a single instrument, the problem of "fitting" the individual patient is greatly simplified, and

2. A patient may find it advantageous to vary the tone control according to the amount and character of ambient noise or the presence of clothing worn over the microphone.

b. The possible value of a characteristic rising 9 db. per octave is still uncertain.

3. Limitation of Maximum Acoustic Output.

Maximum acoustic output should be limited so that the ear is protected against powerful transients.

a. Of the available devices the simplest is the "peak clipper." Properly adjusted peak clipping protects the ear from discomfort and pain while allowing a predetermined maximum amplitude of signal to be delivered. The intelligibility of speech is not seriously reduced by as much as 12 db. of peak clipping.

b. "Compression amplification" produces less amplitude distortion than simple peak clipping and if an effective compressor can be built into a wearable hearing aid it may provide the ideal means of limiting the maximum acoustic output.

4. Desirable Limiting Levels.

The instantaneous acoustic output, measured as pressure under a receiver, at which limiting (by peak clipping or compression) occurs should be definitely established, either by a semipermanent adjustment, or by choice of battery voltage, or by the provision of three or four models with significantly different maximum acoustic outputs. The following permissible ranges are suggested:

Range	Max. instantaneous acoustic output re .0002 dyne/cm^2
Beginners'	110 to 117 db.
Low power	118 to 123 db.
Standard	124 to 129 db.
High power	above 129 db.

The beginners' range is appropriate for individuals who are unaccustomed to loud sounds or are psychologically averse to them. Most of these individuals will, after a period of auditory training, accept (and obtain better results with) a higher limit of acoustic output. The high range will be desired by a small minority of individuals with severe hearing losses and high tolerance thresholds. Their individual earpieces must be fitted with special care to avoid acoustic feedback when maximum gain is employed.

5. Sensitivity, and Freedom from Internal Noise.

The instrument must be sufficiently sensitive and free from electrical or other internally generated noise to allow it to render intelligible to a normal ear speech delivered to it at a level not more than 10 db. above the unaided threshold of intelligibility of that same normal ear.

It is assumed that the test conditions are such that the ambient noise in the test room does not elevate the unaided threshold more than 10 db. above the generally accepted normal standard for the test employed. It is suggested that Auditory test No. 9* or some substantially equivalent recorded test of sensitivity for speech be employed.

6. Acoustic Gain.

Patients' requirements in regard to amplification (acoustic gain) vary so widely that it is probably desirable to design at least two or perhaps three different models of hearing aids. For severe hearing losses a maximum gain for speech of 80 db. should be provided. For mild cases an instrument with a maximum gain of 40 db. or even 30 db. will suffice. A single instrument with a properly designed gain control could cover the entire range of desired amplifications, but it might be unnecessarily large, heavy, and expensive for the patient who never requires more than 30 or 40 db. of acoustic gain. The justification for more than one model is economy of size, weight, and expense; and such considerations may properly determine the maximum gain to be provided by medium-gain or low-gain models. No instrument should, however, have less than 30 db. maximum acoustic gain.

a. "Gain for speech" must be measured with a *defective* ear: one whose "loss for speech" is at least as great as the effective gain of the instrument to be tested. The opposite ear should be masked unless it is already much less sensitive than the ear used for the test. The monaural (free-field) threshold is first determined for the test ear. The listener then wears the hearing aid, using

*Psycho-Acoustic Laboratory report, "Recorded Auditory Tests for Thresholds of Words and Sentences," in preparation.

a well fitting individual earpiece and placing the microphone of the hearing aid in the same position in the acoustic field that was formerly occupied by his ear. His aided threshold is then determined. The difference in decibels between the two thresholds is the "gain for speech" provided by the instrument. Auditory Test No. 9 is recommended for such threshold measurements.

If the loss for speech in the test ear is less than the effective gain of the instrument, one might think that the aided threshold would simply be found below normal. This rarely occurs, however, for at these very low levels the test is interfered with by residual ambient noise in the test room (*e.g.*, the subject's breathing) or by background noise in the apparatus used to deliver the test. These masking factors rather than the acoustic gain of the instrument are apt to determine the aided threshold.

b. A patient's requirements for acoustic gain must not be confused with the maximum acoustic output (Specification 5) that is appropriate for him. Frequently the two run parallel, for the severely hard-of-hearing patient who requires much acoustic gain to understand speech at conversational level is often one who can tolerate a high maximum acoustic output; but sometimes severely hard-of-hearing ears are "tender" and can tolerate only a medium or low acoustic output. Furthermore, acoustic gain and maximum acoustic output are independent properties of hearing aids; and all combinations should be available. To avoid unnecessary and undesirable multiplicity of models it is, therefore, recommended that the appropriate limit of maximum acoustic *output* be provided by semipermanent adjustment (see Specification 5) in each of two or three models that differ in respect to maximum acoustic *gain*. A separate model with low maximum acoustic output combined with low acoustic gain (a "beginners' model") may be justified if considerable further economy of size and expense is attained thereby.

7. Gain Control.

The instrument must be provided with an effective gain control, either continuously variable or with numerous intermediate positions between maximum and minimum. This range should be at least 40 db. The gain control must be designed to avoid accidental or too easy shift of setting, as by contact with clothing, and it should operate roughly linearly on a decibel scale.

8. "Squeal."

There must be no electrical feedback ("squeal") when the instrument is used at maximum gain setting. Acoustic feedback should be dependent on the fit of the earpiece and not on leakage from the receiver itself.

General Comments.

It is anticipated that when instruments conforming to the above specifications are produced the problem of individual selection or "fitting" will almost disappear. It will be necessary only to:

1. Provide a well-fitting individually molded earpiece that is comfortable and at the same time provides adequate acoustic seal, and

2. Select a model with adequate acoustic gain and make the appropriate semipermanent adjustment to provide the proper limitation of maximum power output. Some indoctrination or training may be necessary, however, before the final adjustment to obtain the highest tolerable level of maximum output is made.

It must be clearly recognized by hard-of-hearing patients and their advisers alike, that *even with the most perfect hearing aid, not all cases will achieve entirely satisfactory results.* No instrument can either restore or completely substitute for degenerated sensory cells and nerve fibres. And proper indoctrination in the use of a hearing aid and subsequent auditory training will continue to be of great importance for the severely hard of hearing.

(To be continued in April, 1946, issue.)

FRONTAL SINUSITIS.*

J. M. BROWN, M.D.,
Los Angeles, Calif.

When the diagnosis of acute frontal sinusitis is made at the Los Angeles County General Hospital, penicillin therapy and nasal shrinkage, supplanted with cocaine packs in the middle meatal area, are instituted immediately; if necessary, the middle turbinate may be fractured toward the septum to provide more adequate drainage. An X-ray is taken for anatomical as well as pathological diagnosis.

If the patient's progress is not satisfactory under conservative therapy, the trephine operation for drainage of the frontal sinus is performed early.

Indications for this procedure are as follows:

1. Persistent frontal pain, associated with fever. The presence of these symptoms after three to four hours indicates that adequate drainage has not been established by intranasal shrinkage.

2. Increasing edema over or under the sinus.

3. Moderate symptoms not responding to treatment after 24 hours.

4. If swimming is the etiologic factor, earlier trephine is advisable.

5. Early trephination is also advocated in acute exacerbations of a chronic frontal sinusitis.

TECHNIQUE OF TREPHINE OPERATION.

A general anesthetic, preferably sodium pentothal, is used, and incision is made at the inner angle just below the eyebrow, following novocaine adrenalin instillation for hemostasis.

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The trephine opening is made in the floor of the frontal sinus at its inner angle. A sharp curette or gouge is used for this purpose and the opening is enlarged by a Kerrison forceps.

A rubber tube the size of a lead pencil is inserted into the sinus and held in place by a suture through the skin. No further surgical treatment to the sinus is made at this time. We believe this operation has prevented many serious complications which otherwise might have occurred in these cases.

CLOSURE OF THE TREPHINE OPENING.

The sinus is not irrigated immediately after the trephining. After several days, however, as the drainage becomes less, we irrigate to clean the sinus and more particularly to see if the irrigating fluid will pass into the nose. If the drainage is slight and the irrigating fluid passes freely into the nose, the tube is removed, and the trephine opening is closed with one or two sutures in the skin. The cosmetic results have been exceedingly satisfactory.

If the irrigating fluid does not pass freely into the nose, we attempt to pass a Van Alyea cannula from the nose into the sinus. If this is not successful, a submucous resection of the nasal septum may have to be done, or the removal of one or two anterior ethmoid cells may be necessary to allow free entry of the cannula into the sinus.

Penicillin is used throughout the infection. If given early, it may arrest the entire infection in the sinus. If given late, it will definitely arrest the infection in the sinus and the surrounding areas, but it will not remove pus present in the sinus, or bone, subperiosteally, extradurally, subdurally, or in the form of a brain abscess. These must have surgical drainage in addition to the penicillin. In spite of a normal temperature, few symptoms, and even with a clear spinal fluid at operation we have found pus in the areas.

COMPLICATIONS OF ACUTE FRONTAL SINUSITIS.

I — Complications Through the Floor of the Sinus.

A subperiosteal abscess is frequent in this area. This

should be opened at the time of trephination, or if an abscess forms later it should be opened when the presence of pus is noted. This is the least dangerous complication, but involvement of the optic nerve can occur, resulting in impaired vision.

II — Complications Through the Anterior Wall.

A. Subperiosteal abscess.

B. Osteomyelitis.

C. Thrombosis of the various venous sinuses, especially the superior longitudinal.

If a periosteal abscess is present at trephination, it should be opened; if it develops subsequently, drainage should be instituted. If the osteomyelitis is localized and breaks through the bone, it also should be drained. Since adopting this procedure reasonably early in the process of the disease, we have not had one case of spreading osteomyelitis of the frontal bone.

III — Complications Through the Posterior Wall.

These may include:

A. Extradural abscess.
B. Subdural abscess.
C. Brain abscess.
D. Meningitis.

If the patient presents meningeal symptoms at the time of the trephine, the posterior wall of the sinus should be removed. These symptoms include persistent severe headache and pain over the frontal area, coupled with an increased cell count and pressure in the spinal fluid, with or without the presence of bacteria.

If on removal of the posterior wall the dura bulges into the sinus, drainage should be instituted. Preferably, drainage should be established through a clean area by a skull trephine; however, in several cases a neurosurgeon was not available, and we have drained the abscess through the posterior wall with excellent results.

Dr. C. B. Courville[1] reported 42 cases of subdural abscesses originating from the frontal sinus in patients autopsied at the Los Angeles County Hospital during the 10-year period between 1932-1942. In the year 1945 we had eight patients requiring trephination of the frontal sinuses. Two had extradural abscesses, and two, subdural abscesses. Seven cases made an uneventful recovery, and one with a subdural abscess died of meningitis.

CHRONIC FRONTAL SINUSITIS.

A conservative external operation is here described. This has been successfully used for 20 years in cases when the frontal sinus alone was involved. It is presumed that allergic and endocrine studies have been made, and all anatomical and pathological obstructions in the nose have been corrected; also, that repeated irrigations, together with the other usual forms of conservative therapy, were carried out.

The procedure advocated consists of a Lynch incision and removal of enough of the sinus floor to gain access to all parts of the sinus. All partitions in the sinuses are then removed, together with all the mucosa, except that part in the nasofrontal passageway. This should be carefully preserved. If there are polypi in this passageway, they are removed, but the mucosa proper is left intact. The skin is sutured and a small rubber drain is left in the sinus. As soon as discharge from the tube ceases, it is removed. This procedure has been ably described experimentally and clinically by T. E. Walsh.[2]

REFERENCES.

1. Courville, C. B.: Subdural Empyema Secondary to Purulent Frontal Sinusitis: A Clinicopathologic Study of 42 Cases Verified at Autopsy. *Arch. Otolaryngol.*, 39:3:211-230, Mar., 1944.

2. Walsh, T. E.: Experimental Surgery of the Frontal Sinus. The Rôle of the Ostium and Nasofrontal Duct in Postoperative Healing. The Laryngoscope, LIII:2:75-92, Feb., 1943.

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